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# MINOR STUDIES FROM THE PSYCHOLOGICAL LABORATORY OF CORNELL UNIVERSITY

## LVIII. AN EXPERIMENTAL INVESTIGATION OF THE EXPERIENCE WHICH ACCOMPANIES THE SUDDEN CESSATION OF AN AUDITORY STIMULUS

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In his experiments upon the positive after-image in audition Bishop<sup>1</sup> found that a physically sudden cutting off of his stimulus-tones was not accompanied by a sharply ending tone for sensation. The transition from full tone through the changed character of the auditory experience to the ultimate disappearance of all sound of the tone he called the "modified ending." Throughout his experiments he tried to eliminate this modified ending, but was never successful. He concluded, at the end of his research, that the modified ending might be "due in part to tonal *Abklingen*, in larger part to the objective conditions" of his experimental arrangement.<sup>2</sup>

### PROBLEM

It is the purpose of this study to continue the investigation of the modified ending. Not every *O* had reported the modified ending at every stimulation. Only a few experiments were made by Bishop in which his *Os* were instructed to listen for it at every stimulation. These few led him to believe that it was always present, but the evidence supporting this belief was confined to the data obtained from a few experiments made at the end of his work. The fitful manner in which the modified ending made its way into the reports of his *Os* was the source of so much annoyance, that he sought relief from its irregularity of appearance in the possibility that it was really always present, and that his instructions to the *Os* had diverted them from it, so that they reported it only when it was sufficiently striking to force itself upon them. Our own first task, then, was to extend the number of experiments made under the instruction to listen for the modified ending at every stimulation, and thus to discover, if possible, what its existential character might be.

### EXPERIMENTAL

Bishop's results indicated that the apparatus used in Series II<sup>3</sup> of his experiments could be utilized for our experiments. In that form it was simpler and more easily kept in adjustment than in some of his later forms. The only change from his arrangement in our first group of experiments was the omission of the sound-proof box. We decided that this would not be needed, because any echo would follow the final portion of the modified

<sup>1</sup>H. G. Bishop, "An Experimental Investigation of the Positive After-Image in Audition," this JOURNAL, 32, 1921, 305-325.

<sup>2</sup>*Ibid.*, 325.

<sup>3</sup>*Ibid.*, 310.

ending and would, consequently, not interfere with the observation. With only the summer term of six weeks at our disposal we confined ourselves at the start to one pitch, 512 vs, at the three intensities used by Bishop.<sup>4</sup>

*Observers.* The Os were Assistant Professor Josephine Gleason of Vassar College, and Assistant Professors K. M. Dallenbach and L. B. Hoisington, Dr. H. G. Bishop, and Miss C. C. Braddock (graduate student in psychology), of Cornell University. All Os were experienced, but Bi was more practised in observation of the modified endings than the others.

*Instructions:* "You will hear a tone which will be cut off suddenly. About two seconds before it is cut off the signal flag will fall as a warning. In attributive terms, describe any change in the tone which occurs as it is going off."

#### SERIES I

In this series Bi, Br, D, and G were given 30 stimuli in haphazard order, 10 at each one of the three intensities. We found that echo, particularly at the higher intensities of stimulation, was a distraction, and that the stimulus-tone must therefore be enclosed in a sound-proof box. Every O except G, who unfortunately described the echo, reported some kind of transitional ending for every tone. This regularity was highly satisfactory; but the lack of uniformity in the descriptions of the nature of the modified ending was less comforting. The characteristics of the modified ending which were commented upon referred to its pitch, intensity, and volume, and to phases of it which are similar to certain phonetic sounds like labials and aspirates, such as "plop," "whoop," or "breathiness." Besides these there were less frequent reports that the modified ending was "noisier," "less singing," "less brilliant," "more blunt" than the tone. It was a "rustling" to which no pitch could be assigned, it "thinned," and was "hollower" than the tone. We give below a summary of the results for every O. S, M, and W refer to the three intensities, and the numbers designate the number of reports covering the characteristic of the "modified ending" to which O referred.

#### PITCH

Bi: S, flatting 8; M, flatting 5, sharpening 3; W, flatting 2, sharpening 3  
 Br: S, sharpening 2; M, flatting 1, sharpening 4; W, flatting 2, sharpening 1  
 D: S, sharpening 6; M, flatting 1, sharpening 4; W, flatting 0, sharpening 3

#### INTENSITY

Bi: S, less 3; M, no reference; W, greater 1  
 Br: S, greater 2, less 1; M, less 2; W, greater 1, less 4  
 D: S, greater 1, less 6; M, less 7; W, greater 0, less 4

#### VOLUME

Bi: no reference  
 Br: S, less 1; M, no reference; W, no reference  
 D: S, less 7; M, less 4; W, less 3

#### DURATION

The modified ending is practically instantaneous, and most reports do not refer to its length. Occasionally, however, a very short or an unusually long ending is mentioned.

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<sup>4</sup>*Ibid.*, 307.

This summary was made by counting the number of recurrences of any report by any *O*, and took no account of the fact that the stimulus-tones, presented to all *Os* at the same time, furnished another measure of the degree of agreement among *Os*. We found, upon investigation, that there was about the same amount of contradiction among *Os* whether we compared the reports as they are given in the summary or whether we compared the reports of all *Os* for the same tone.

Observation of the modified ending is very difficult; indeed, it is so difficult that we trusted to practice and the elimination of echo to bring the uniformity of report which we desired. Without further change than the boxing-up of the variator we proceeded with Series II.

### SERIES II

In this series 60 stimuli were presented in haphazard order, 20 for every intensity. The same contradictions which we found in Series I appeared again; but practice worked a change in the kind of report, which altered the significance of the contradictions. In the beginning the modified ending was baffling to every *O*. It is very short; and, since it begins with a tone, there was strong predisposition to regard it as tonal and to assign tonal attributes to it. Our instructions favored this kind of report, though they did not exclude references to other observational characters which the modified endings might show. Reference to these other characters came earlier in the reports of some *Os* than in others, but the course of change within the reports of all *Os* was similar. They began, as we have indicated, with references to pitch, intensity, vocal character, and more infrequently to volume. Soon they began to mistrust their observations of pitch and said "doubtful rise" or "doubtful fall." Another development was the increasing observable complexity of the ending. It was not unitary but complex, and had a well-marked temporal course in spite of its brevity. It began with tone and ended with something more noisy, and during its course it seemed that the tone died away as the noise increased. This shift was expressed sometimes as a vocal change like oo-oop, and sometimes as an "aspirate" character or a "breathiness." Sometimes there was said to be a change in relative intensity or relative volume between the two phases of the ending. Everyone heard a decided change in the ending of every tone, but to give a verbal account of it severely tested every *O*'s descriptive and observational ability. The results showed further that the different *Os* attended to different aspects of the ending, and this fact produced heterogeneity of report even when there was the unifying factor of simultaneous observation of the stimulus-tones. The descriptions were so varied that unification into a typical modified ending for every intensity was well-nigh impossible. Every intensity gave the ending, and the stronger the intensity the more complex and more striking was the ending. Since it was our task to reduce the variability of the descriptive accounts, we made a second shift in technique for Series III, in which we used the weak stimulus only, on account of its simpler ending.

### SERIES III

In spite of variability in what the *Os* said about the nature of the modified ending (57 stimuli in this series), there remains the more pertinent fact that some kind of transitional ending to the tones was always found. We desired first to secure evidence that tones were never cut off sharply for sensation, and secondly to find out what we could about the observable character of the ending. Throughout our study we have always found that the tones showed definite transformation as they died away.

Even though we did not find identity and full agreement in the descriptions, their very differences can be turned to good account. The

differences indicated that the *Os* either were not picking out the same aspects of the modified ending for report, or were observing under different degrees of proficiency due to different degrees of practice. To make a descriptive composite picture of the modified ending from the data at our disposal may be presumptuous; but we hazard such a picture, for it should be harmless, if it is regarded as a tentative construction, and should be useful as a stimulus to further experimentation.

There is a temporal course to the modified ending which begins with the first noticeable change in the character of the tone and continues until complete silence has set in. The verbal account will suggest that the modified ending is relatively long; but such a conception is highly erroneous; for its duration is of the same order as that of the click of a telegraph sounder. The pitch, which was clear and ringing during the tone, suddenly is encroached upon by a new quality which is said to be "breathy," "noisy," "hissy," etc. These two exist together, as flowing experiences, not static. The tonal part diminishes and the noisy part increases. The original tonal character to which the pitch was assigned very soon disappears. It is impossible, from the reports, to say whether it dies without change, whether it grows more shrill, as if it were present at a higher degree of attributive clearness, or whether it perhaps undergoes some other change. At this stage the experience is both tonal and noisy, and it is difficult to decide whether the tone-noise compound has a new pitch, or whether it is nonsense to speak of pitch at all. All agree that this stage is qualitatively different from the pure tone; and it is certain that the flattening or sharpening reported is not the pitch-change of the musical slur. Following this middle stage, the tonal character diminishes to zero and the noise component reaches its maximum. The course of the noise begins with the breathiness which has already been mentioned and progresses into something hissy resembling the sound of *s* in *this*. It is very much softer and more breathy than *s* but is similar to it. The *s* passes over into a very soft, non-explosive, aspirated *p* similar to *p* in *up*, especially to that part of the *p* which is made by closing the lips as the breath comes against them; but not to the explosive part which accompanies the opening of the lips and the release of the compressed air in the mouth cavity. The modified ending could not be imitated accurately by any *O* in speech; but phonetic elements were easily recognizable in it, even if there was not full agreement about the letter which best expressed them. It is somewhat uncertain whether the tone continues until the end of the modified ending; some reports say that it does, others that it does not. In the matter of intensity there is also uncertainty. It seems probable that the general intensity of the modified ending is less than the intensity of the tone, although the weakening in the tonal component may perhaps be compensated by an increasing intensity of the noisy component. As regards the vowel quality of the tone, there is fairly general agreement that it is the phonetic *o*, or an admixture of another vowel with *o*. The clear vowel is, however, clouded by an admixture of the noise already described. Naturally, attributive volume has no significance if the pitch is constant. Reports on pure attributive volume were made much more infrequently than on other characters, if they were ever made. We are of the opinion that the coloring of noise rendered it impossible to judge pure tonal volume.

This, then, completes the picture which expresses the best founded generalizations from the results of Series III. It had to be pieced together from reports which were not the result of simultaneous attention of the *Os* to the same aspect of the tones. We hoped, therefore, to obtain greater uniformity by requesting them to attend in one set of observations to pitch, in another to vocality, and in a third to intensity. We devoted an hour's observation to each one, and finished the experimentation by a return for an hour to the instructions of Series III.

## SERIES IV

*Instructions:* "Pick out the most striking pitch in the tone, during its course, and listen to it to see if it remains the same in the modified ending, or if it changes. If it changes, report the direction of change. If the pitch drops out before the end of the modified ending, tell what it is that follows."

The effect of this instruction was a gain only in this, that the reports made were on pitch. G said the pitch dropped; Br found that it sometimes rose, sometimes fell, sometimes remained the same; for D it generally dropped; for Bi it remained the same until it vanished. All alike reported an occasional lag of something breathy or aspirate after the tone had ceased. Since Bi is the most practised O, and since he too, during the earlier observations, reported a change in pitch, we suggest that more practice for the other Os might bring them to the same conclusion. H, who is a highly practised O, in the few observations which he made judged that the pitch dropped out, and that in so far as he could assign pitch to the non-tonal or less tonal aspirate part of the modified ending it flattened at the very end. This report is partial agreement with Bi, at any rate; the reports of Bi in some cases say that there is a different character at the end of the modified ending, which seems to be of lower pitch than the tone.

*Instructions:* "In this set of experiments you are to give your attention to the vowel quality. If there is a perceptible transition in the vowel quality from the ending of the tone to the ending of the modified ending, express this transition in phonetic characters; and describe it more fully, if possible, in whatever additional terms you choose."

Except for G, who said there was no change in vowel quality, every O reported a transition. For some it began with almost pure *o*, for others with about equal purity of *u*; it finished with something resembling explosiveness expressed by *p*, *h*, or *t*. Br inserted *e* and *i* during its course, but no other O indicated intermediate stages.

*Instructions:* "In this set of experiments you are to give your attention to intensity. Report the direction of any perceptible change in it, and add whatever additional description you can."

Again there was disagreement. The different Os did not agree either with themselves or with one another. All reported increase, decrease, and the same intensity. We suggest that the irregularity may be due in part to a confusion of intensity and attributive clearness. Bi reported "shrillness" which he never defined; but it seemed to resemble either a rise in intensity or an increase in clearness.

*Return to Original Instructions.* The added practice and the successive direction of attention to pitch, vowel quality, and intensity had a unifying effect upon the reports of pitch. Every O except D said that the pitch dropped out rather than changed; D reported, in several cases, that it was the same, with one report that it rose. In other respects the data taken in this last hour were typical of what has been said in the generalized description of Series III.

*Conclusions.* (1) We always found the modified ending of Bishop's experiments.

(2) The modified ending is certainly qualitatively different from the stimulus-tone; but we cannot be positive about changes in other respects.